Lengths of the First Days of the Universe

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Abstract. The early stage of the Universe is discussed and the time lengths of its first days are given. If we denote the Hubble time in the zero-gravity limit by τ (approximately 12.16 billion years), and T_n denotes the length of the n-th day, then we have the very simple relation $T_n = \tau/(2n-1)$. Hence we obtain for the first days the following lengths of time: $T_1 = \tau$, $T_2 = \tau/3$, $T_3 = \tau/5$, etc.

In this Note we calculate the lengths of days of the early Universe, day by day, from the first day after the Big Bang on up to our present time. We find that the first day actually lasted the Hubble time in the limit of zero gravity. If we denote the Hubble time in the zero-gravity limit by τ which equals about 12.16 billion years and T_n denotes the length of the n-th day in units of times of the early Universe, then we have a very simple relation

$$T_n = \frac{\tau}{2n-1}. \tag{1}$$

Hence we obtain for the first few days the following lengths of time:

$$T_1 = \tau, \quad T_2 = \frac{\tau}{3}, \quad T_3 = \frac{\tau}{5}, \quad T_4 = \frac{\tau}{7}, \quad T_5 = \frac{\tau}{9}, \quad T_6 = \frac{\tau}{11}. \tag{2}$$

It also follows that the accumulation of time from the first day to the second, third, fourth, ..., up to now is just exactly the Hubble time. The Hubble time in the limit of zero gravity is the maximum time allowed in nature.

Using Cosmological Special Relativity [1-4], the calculation is very simple. We assume that the Big Bang time with respect to us now was $t_0 = \tau$, the time of the first day after that was t_1, the time of the second day was t_2, and so on. In this way the time scale is progressing in units of one day (24 hours) in our units of present time. The time difference between t_0 and t_1, denoted by T_1, is the time as measured at the early Universe and is by no means equal to one day of our time. In this way we denote the times elapsed from the Big Bang to the end of the first day t_1 by T_1, between the first day t_1 and the second day t_2 by T_2 and so on. According to the rule of the addition of cosmic times one has, for example,

$$t_6 + 1(day) = \frac{t_6 + T_6}{1 + t_6 T_6/\tau^2}. \tag{3}$$

A straightforward calculation then shows that

$$T_6 = \frac{\tau^2}{\tau^2 - (\tau - 6)(\tau - 5)} = \frac{\tau^2}{11\tau - 30}. \tag{4}$$

In general one finds that

$$T_n = \frac{\tau^2}{\tau^2 - (\tau - n)(\tau - n + 1)}, \tag{5}$$

or

$$T_n = \frac{\tau}{n + (n - 1) - n(n - 1)/\tau}. \tag{6}$$

As is seen from the last formula one can neglect the last term in the denominator in the first approximation and we get the simple Eq. (1).

From the above one reaches the conclusion that the age of the Universe exactly equals the Hubble time in vacuum τ, i.e. 12.16 billion years, and it is a universal constant [6]. This means that the age of the Universe tomorrow will be the same as it was yesterday or today.

But this might not go along with our intuition since we usually deal with short periods of times in our daily life, and the unexperienced person will reject such a conclusion. Physics, however, deals with measurements.

In fact we have exactly a similar situation with respect to the speed of light c. When measured in vacuum, it is 300 thousands kilometers per second. If the person doing the measurement tries to decrease or increase this number by moving with a very high speed in the direction or against the direction of the propagation of light, he will find that this is impossible and he will measure the same number as before. The measurement instruments adjust themselves in such a way that the final result remains the same. In this sense the speed of light in vacuum c and the Hubble time in vacuum τ behave the same way and are both universal constants.

The similarity of the behavior of velocities of objects and those of cosmic times can also be demonstrated as follows. Suppose a rocket moves with the speed V_1 with respect to an observer on the Earth. We would like to increase that speed to V_2 as measured by the observer on the Earth. In order to achieve this, the rocket has to increase its speed not by the difference $V_2 - V_1$, but by

$$\Delta V = \frac{V_2 - V_1}{1 - V_1 V_2 / c^2}. \tag{7}$$

As can easily be seen ΔV is much larger than $V_2 - V_1$ for velocities V_1 and V_2 close to that of light c. This result follows from the rule for the addition of velocities,

$$V_{1+2} = \frac{V_1 + V_2}{1 + V_1 V_2 / c^2}, \tag{8}$$

a consequence of Einstein's famous Special Relativity Theory [5]. In cosmology, we have the analogous formula

$$T_{1+2} = \frac{T_1 + T_2}{1 + T_1 T_2/\tau^2} \tag{9}$$

for the cosmic times.

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